

# Science Didactic Competencies Development in Teacher Training Colleges. Perspectives of Final Year Students at Nyamata TTC in Rwanda

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DOI: <https://doi.org/10.47772/IJRISS.2026.10200109>

Received: 04 February 2026; Accepted: 11 February 2026; Published: 25 February 2026

## ABSTRACT

Science didactic competencies development is essential in teacher training because it equips pre-service teachers with the pedagogical skills, practical knowledge, and instructional strategies necessary to effectively teach science and foster student understanding. This study investigated the perceptions of final-year students at Nyamata TTC in the Eastern province of Rwanda regarding the effectiveness of science didactic competencies development within their teacher training program. The purpose was to examine how well the college prepares pre-service science teachers in key didactic competencies, including lesson planning and curriculum interpretation, pedagogical content knowledge, inquiry-based learner-centered teaching, practical and laboratory skills, assessment and evaluation, and classroom management and communication. A descriptive research design was employed, guided by Shulman's Pedagogical Content Knowledge (PCK) Theory (Shulman, 1986). It used quantitative approach to collect data with structured questionnaire administered to 96 final-year students. Data were analyzed using descriptive statistics to determine the levels of confidence across the different competency areas. The results indicated that the majority of students expressed high confidence in most competencies, particularly in lesson planning, assessment and evaluation, and classroom management. However, a relatively low confidence was noted in areas such as improvising teaching aids using locally available materials, integrating ICT tools, and managing large classes. The study concluded that Nyamata TTC's teacher training program effectively develops core science didactic competencies, but it requires enhanced support in resourcefulness and technology integration to fully prepare graduates for real classroom conditions. It is recommended that the college strengthen innovative teaching aid development, and enhance ICT integration to bridge the gap between training and classroom realities.

## INTRODUCTION AND BACKGROUND

Teachers are widely recognized as the cornerstone of quality education systems. Effective teacher preparation is essential not only for improving instructional practices but also for enhancing student learning outcomes. Teaching skills are essential parts of teachers' professional development and play important roles in teachers' daily practice in classroom. Teachers use teaching skills to design, teach and organize learning activities inside and outside classrooms. The development of teaching skills requires the application of general skills to the classroom setting in a variety of ways (Zhao, Jiao, 2012).

In a teacher training program, the didactic competence refers to a teacher's ability to plan, deliver, and evaluate instruction in ways that effectively promote student learning. It goes beyond knowing the subject matter and focuses on how that knowledge is taught and made meaningful to learners.

In Rwanda, Teacher Training Colleges (TTCs) are the main institutions tasked with preparing prospective teachers to effectively implement the national curriculum, including science subjects. These colleges are responsible for developing qualified educators who demonstrate both solid subject matter knowledge and the pedagogical skills necessary to actively engage learners within a Competence-Based Curriculum (CBC) framework. Education reforms have emphasized the importance of producing teachers who are not only knowledgeable in their subject areas but also equipped with the pedagogical skills necessary to implement learner-centered approaches.

Since the rollout of the Competency-Based Curriculum in Rwandan basic education in 2016, there has been a major shift from traditional, knowledge-oriented instruction towards teaching practices that emphasize practical, real-world application of skills and learner-centred approaches (Habiyaemye et al., 2023). To support this shift, Teacher Training Colleges have had to align their programmes with CBC goals so that graduating teachers are equipped with the requisite competencies to implement learner-centred science instruction (REB Curriculum Framework for TTCs, 2020). This alignment is meant to ensure that pre-service training not only conveys science concepts but also develops didactic competencies, the ability to plan, deliver, and assess science lessons using appropriate methods, strategies, and resources. These competencies are central to the transformation envisioned by CBC, as they directly influence how teachers facilitate conceptual understanding and practical application in science classrooms. Moreover, pedagogical content knowledge and positive teaching attitudes are also critical in shaping future teachers' readiness to implement effective science instruction (Brendle & Piazza, 2017).

Despite these reforms, the implementation of CBC and related teacher competencies faces persistent challenges in Rwandan teacher education. In some cases, TTCs have struggled to fully adopt CBC-aligned courses and methodologies, leading to gaps in trainees' preparedness to teach competence-based science lessons upon graduation. Similarly, science and mathematics education research within Rwandan TTCs points to variability in pedagogical skills and content knowledge among pre-service teachers, highlighting the complexity of translating curricular reforms into effective classroom practices (Habiyaemye et al. 2023).

Given these systemic transformations and challenges, it is important to explore how science didactic competencies are developed within Rwanda's TTCs from the lived experiences of those directly involved in the process, final-year student teachers. Nyamata TTC, as one of Rwanda's established teacher training institutions, provides a relevant case for understanding both the strengths and limitations of current pre-service science didactic training. Such inquiry can offer nuanced insights into how science teacher education programmes prepare future educators, how trainees perceive the effectiveness of such preparation.

This study, therefore, seeks to investigate science didactic competence development within the context Nyamata TTC, focusing on the perceptions of final-year students. By examining perceived preparation practices and real classroom experiences, the study aims to contribute to ongoing discussions about enhancing teacher education quality to support better and improved science teaching.

### **Lesson Planning and Curriculum Interpretation**

Lesson planning and curriculum interpretation competencies refers to a teacher's ability to understand the science curriculum, identify learning outcomes, and translate them into coherent, learner-centred lesson plans. This includes aligning objectives, content, teaching strategies, learning activities, and assessment methods with the Competence-Based Curriculum (CBC). In science education, effective lesson planning ensures that concepts are sequenced logically and linked to real-life contexts to enhance learners' understanding and application of scientific knowledge (REB, 2020).

This competence is particularly important in CBC settings because teachers are expected to focus on the development of skills, attitudes, and values rather than content coverage alone. Pre-service science teachers must therefore demonstrate the ability to design inquiry-based and activity-oriented lessons that promote problem-solving and critical thinking. Moreover, well-structured lesson plans support consistency across instructional delivery and promote reflective teaching. Teachers who plan with clear goals and anticipated learner outcomes can make intentional choices about instructional materials and pacing, increasing the likelihood of meeting diverse learner needs (Marzano, 2007). Research indicates that novice teachers who engage in detailed planning aligned with curriculum standards demonstrate higher instructional quality and greater student achievement in sciences (Hammond et al., 2017).

### **Pedagogical Content Knowledge (PCK)**

Teachers should be able to integrate subject matter knowledge with appropriate teaching strategies to make science concepts understandable to learners. It involves knowing what teaching approaches, representations, and

explanations best suit particular scientific topics and learner levels. According to Shulman (1987), PCK is the foundation of effective teaching because it bridges the gap between knowing science and teaching science.

In science didactics, strong PCK enables teachers to anticipate learners' misconceptions, select suitable demonstrations or experiments, and adapt explanations to diverse learner needs. Research in teacher education shows that pre-service teachers with well-developed PCK are more confident and effective in classroom practice, particularly in implementing inquiry-based and learner-centred instruction. Strong PCK is a key determinant of effective teaching because it enables teachers to present content in ways that bridge learners' prior knowledge and new ideas (Ball et al., 2008). Teachers with developed PCK also anticipate areas of difficulty, adjust instruction responsively, and create connections between abstract representations and learners' experiences, thereby enhancing engagement and achievement (Depaepe et al., 2013).

### **Inquiry-Based and Learner-Centred Teaching**

Inquiry-based and learner-centred teaching competence involves the ability to engage learners actively in the learning process through questioning, exploration, experimentation, and discussion. In science education, this competence emphasizes learners' active construction of knowledge rather than passive reception of information. The CBC framework strongly advocates inquiry-based approaches as a means of developing scientific reasoning, creativity, and problem-solving skills (Attard et al., 2021). Students who engage in activity-based instruction show higher levels of problem-solving ability and conceptual understanding than peers in traditional lecture-based settings (Boaler, 1998). These approaches also foster student autonomy, motivation, and confidence in mathematics. Such strategies are aligned with constructivist theories which emphasize that learners build new knowledge based on prior understanding through active engagement.

For pre-service science teachers, developing this competence requires practical exposure to learner-centered methodologies such as group work, project-based learning, and guided experiments. However, studies indicate that many trainee teachers struggle to shift from traditional lecture-based approaches due to limited experience, large class sizes, and insufficient instructional support (OECD, 2019). Strengthening this competence is therefore essential for effective science teaching in TTCs.

### **Designing and Conducting Problem-Solving Activities**

Problem-solving is at the heart of science education because it drives learners to apply knowledge creatively in unfamiliar contexts. Designing effective problem-solving tasks requires teachers to select or construct problems that are challenging, relevant, and accessible to learners while aligned with curriculum outcomes. Such problems encourage learners to plan, test hypotheses, and articulate reasoning processes.

Conducting problem-solving activities involves not just presenting problems but facilitating learner discussion, monitoring strategies, and providing feedback. Research highlights that classrooms emphasizing problem solving help learners develop flexible thinking and resilience when confronting complex tasks (Schoenfeld, 1992). Furthermore, teachers' skills in orchestrating productive problem-solving discussions contribute significantly to student learning gains.

### **Practical and Laboratory Skills**

A teacher's ability to design, conduct, and supervise science experiments and hands-on activities safely and effectively is essential for quality teaching. This includes selecting appropriate materials, guiding learners through experimental procedures, and helping them interpret results. Practical work is a core component of science education because it allows learners to observe, test, and apply scientific concepts in real-world contexts (Hofstein & Lunetta, 2004).

In teacher training colleges, the development of this competence prepares future teachers to foster scientific inquiry and experiential learning in schools. However, research highlights that inadequate laboratory facilities, limited resources, and insufficient practice time can hinder the acquisition of practical skills among pre-service

teachers (Ndiokubwayo, 2017). Addressing these constraints is critical for improving science didactic competence development in TTCs.

### **Proficiency in assessment and evaluation**

Assessment and evaluation competencies involves the ability to design and use appropriate assessment tools to measure learners' achievement of science competencies. In a CBC framework, assessment goes beyond written tests to include formative assessments, performance tasks, practical activities, and learner portfolios. Effective science teachers use assessment to monitor learning progress, provide feedback, and support continuous improvement (Nakawuki et al., 2025).

Pre-service teachers must therefore develop skills in competence-based assessment, including setting clear performance criteria and using assessment results to inform instruction. Studies indicate that many trainee teachers find it challenging to design authentic assessment tools aligned with competencies, often relying on traditional testing methods (OECD, 2019). Strengthening assessment competence is essential for ensuring meaningful evaluation of science learning outcomes. Teachers must also interpret assessment data to provide targeted feedback and adjust instruction accordingly. Research indicates that when teachers use assessment formatively to guide teaching decisions, student achievement in mathematics improves significantly (Black & Wiliam, 1998). Developing assessment literacy is therefore integral to effective mathematics didactic competence.

### **Classroom Management and Learning Environment**

Pre service teachers need to be trained to create a safe, inclusive, and supportive environment conducive to science learning. This includes managing learner behaviour, organizing classroom activities, and promoting positive interactions during experiments and group work. Effective classroom management is particularly important in science lessons, where practical activities require careful supervision and organization (Emmer & Sabornie, 2015).

This competence supports the successful implementation of learner-centred and inquiry-based approaches. Research shows that inadequate classroom management skills can discourage teachers from using interactive methods, leading them to revert to teacher-centred practices (OECD, 2019). Developing this competence during teacher training enhances confidence and instructional effectiveness.

### **Use of Technology and Digital Tools in Teaching**

The effective use of technology and digital tools in teaching is increasingly recognized as essential for pre-service science teachers because it enhances instructional quality and prepares future educators for modern classroom demands. Digital tools such as simulations, virtual labs, and interactive multimedia resources help pre-service teachers represent complex scientific concepts in ways that are more accessible and engaging for learners, thereby promoting deeper conceptual understanding and inquiry-based learning (Estrada, 2022). Moreover, technology supports the development of 21st-century skills, including critical thinking, creativity, and collaboration, which are indispensable for both teachers and students in science education contexts

Research on pre-service teachers' technological pedagogical content knowledge highlights that integrating digital tools into hybrid and face-to-face science instruction improves lesson delivery and encourages pedagogical innovation, although structured training is necessary to address gaps in technological proficiency (Estrada, 2022). The expanding role of technology in education also reflects broader policy and curriculum expectations that require teacher educators to equip future teachers with the ability to leverage digital resources effectively, not only to support content delivery but also to personalize learning and conduct formative assessment (Wibowo, 2024). Without adequate preparation in the use of educational technology, pre-service science teachers may struggle to adapt to diverse learning environments and to facilitate engaging, student-centred learning experiences that reflect current scientific practice and educational standards. Thus, developing strong skills in technology integration is foundational to producing science teachers who can enhance learner engagement and achievement in a digitally evolving world.

However, the effective use of technology requires more than access; it demands teacher competence in selecting appropriate tools and integrating them into pedagogical activities. Research reports that technology-rich instruction enhances engagement and problem solving when teachers design tasks that exploit the unique affordances of digital tools (Hegedus & Dalton, 2015). Professional development that focuses on pedagogical integration of technology is therefore critical.

### **Reflective Practice and Self-Evaluation for Instructional Improvement**

Reflective practice is the process by which teachers critically analyze their instructional decisions, student outcomes, and professional growth. Through reflection, teachers identify what worked, what did not, and how their pedagogical choices impact learner understanding. Self-evaluation fosters continuous improvement and helps teachers adapt practices to better support learners.

Research underscores that reflective teachers are more responsive to student needs and more intentional in refining their instruction (Loughran, 2002). For pre-service teachers, developing habits of reflection supports long-term professional development and enhances instructional quality in mathematics teaching.

### **Theoretical Framework**

This study is guided by Shulman's Pedagogical Content Knowledge (PCK) Theory. Pedagogical content knowledge, or PCK is a construct coined by Lee Shulman (1986) to emphasize the importance of studying teacher professional knowledge, and teacher knowledge of subject matter in particular. The theory posits that effective teaching requires the integration of subject matter knowledge with pedagogical strategies, enabling teachers to present content in ways that students can understand.

Shulman defined PCK as a special kind of knowledge possessed by experienced teachers that constitutes a fusion of subject matter knowledge and the pedagogy appropriate for teaching particular topics. It includes knowledge about learners and how to represent subject matter knowledge in forms that make it comprehensible to students.

According to Shulman, this knowledge distinguishes the subject matter pedagogue from the subject matter specialist; the former understands the subject in a different way from the latter. This entry first describes the intellectual context within which the construct was proposed and then describes different conceptualizations of the nature of PCK (Maher, 2005).

In his first article in 1986, which introduced the concept of PCK, Shulman presented PCK as a subcategory of teacher content knowledge, the other two being subject matter content knowledge and curricular knowledge. He conceptualized PCK as a specific form of content knowledge that is relevant to its teaching. It is topic specific, that is, related to the most regularly taught topics in a teacher's subject specialization. Additionally, it includes forms of representation of the content, namely, the analogies, illustrations, examples, explanations, demonstrations, and activities that make the content comprehensible to students. Finally, it includes knowledge about student difficulties in learning the content of the topic and how to overcome these difficulties. These include students' alternative conceptions and misconceptions and how to engage with these prior ideas that students hold and that often hamper effective learning.

Hashweh (2013) revisited the PCK research landscape and portrayed specific cases of successful teaching and develops subject-matter-specific models of teacher learning and professional development grounded in PCK. He emphasizes that understanding effective pedagogical content knowledge requires situating it within the actual practice of teaching, rather than treating it as an abstract or generic body of knowledge.

Hashweh's reconceptualization has important implications for teacher education and research. It suggests that teacher preparation and professional development should focus on helping teachers build their own pedagogical constructions through practice, reflection, and interaction with content and learners, rather than merely teaching general pedagogical principles. This perspective insists that PCK develops over time and is refined through repeated engagement with specific content in the classroom.

Hashweh(2013) proposes seven core assertions about the nature of PCK: PCK is personal and private meaning that it resides in the teacher's mind and practice rather than as impersonal, generic knowledge, PCK is composed of teacher pedagogical constructions (TPCs), distinct units created through experience, These constructions are generated not only through lesson planning but also during active classroom teaching and subsequent reflection, The development of TPCs emerges from an inventive process influenced by the interaction of multiple knowledge and belief categories (e.g., subject matter knowledge, pedagogical knowledge, beliefs about learners), TPCs function as both event-based and story-based memories linked to specific teaching episodes and rich practical knowledge, They are topic-specific meaning that PCK for one subject matter topic is different from another, Ideally, these constructions should be labeled and connected to other teacher knowledge domains to clarify their relations and facilitate research.

Shulman's Pedagogical Content Knowledge theory provides the theoretical framework for conceptualizing and developing didactic competencies among final-year science teacher trainees in Teacher training colleges, emphasizing the inseparability of content mastery and pedagogical skills, and foregrounding the teacher's capacity to transform content for learners. The study of trainee perspectives on didactic competence development, therefore, can be interpreted through Shulman's lens of PCK, as it highlights how trainee teachers understand, value, and feel prepared to integrate content knowledge with appropriate teaching strategies in their future classrooms.

## **MATERIALS AND METHODS**

This study adopted a descriptive research design, which is suitable for in-depth exploration of a phenomenon within its real-life context (Yin, 2018).

The target population of this study comprises all final-year students enrolled in the Science and Mathematics Education (SME) program at Teacher Training College (TTC) Nyamata in Rwanda. These students represent a critical group for the investigation because they are at the final stage of their teacher preparation and have completed most of the coursework, teaching practice, and pedagogical training related to science didactic competencies. As prospective science teachers, their experiences and perceptions provide relevant and reliable insights into the extent to which didactic competencies are developed during teacher training.

The sample for the study consists of all 96 final-year students in the SME program at TTC Nyamata. Since the total number of students in the target population is relatively small and manageable, the study adopts a census approach, whereby every individual in the population is included in the sample This ensures that the findings represent the views of the entire population of interest and eliminates sampling error that could arise from selecting only a subset of students (Ansari, 2022). Therefore, 96 final-year students in SME were purposively selected to participate in the research process.

Quantitative data on students' perceptions of their confidence in the development of science didactic competence, as well as the related challenges, were collected using a structured questionnaire. The data were analyzed using appropriate statistical techniques, with descriptive statistics such as frequencies and percentages employed to systematically summarize and interpret the findings

## **RESULTS AND DISCUSSIONS**

### **Students Confidence in Science Didactic Competence Development**

#### **Lesson planning and curriculum interpretation**

Lesson planning and curriculum interpretation are fundamental competencies for effective teaching and learning. Lesson planning provides a structured framework that guides instructional delivery, ensuring that learning objectives, content, activities, and assessment are aligned to promote meaningful student engagement (Brown & Jones, 2021). Similarly, curriculum interpretation enables teachers to translate broad curriculum goals into practical classroom practices, ensuring that lessons reflect educational standards and meet learners' needs (Johnson, 2018). Developing competence in these areas is therefore essential for producing coherent, goal-

oriented instruction and for fostering improved learning outcomes The following section presents the results of the study, examining students’ perceived confidence, using descriptive statistical measures such as frequencies(F)and percentages (%) for systematic analysis.

Lesson planning and curriculum interpretation	Very Confident		Confident		Moderately confident		Total	
	F	%	F	%	F	%	F	%
Write clear and measurable science lesson objectives.	82	85.5	14	14.5	0	0	96	100
Select appropriate teaching methods for science lessons.	78	81.3	18	18.7	0	0	96	100
Integrate learner-centered approaches in a science lesson	87	90.6	9	9.4	0	0	96	100
Plan lessons that consider learners’ prior knowledge	93	96.9	3	3.1	0	0	96	100

Source: Primary data (2026)

The findings of this study reveal that the majority of students demonstrated high confidence in writing clear and measurable science lesson objectives, with **82 (85.5%)** reporting they were very confident, while only 14 (14.5%) were confident. This suggests that most students perceive themselves as capable of formulating precise learning outcomes, which is essential for effective instructional planning and assessment. The literature further highlights that clear and measurable objectives are foundational to effective instructional design and contribute to improved educational outcomes by aligning teaching and assessment more tightly with what students are expected to learn. Well defined objectives help teachers to determine what learners should be able to do at the end of a lesson and provide a benchmark for evaluating learning outcomes.

Similarly, Anderson and Krathwohl (2001) argue that measurable objectives support effective curriculum implementation by making learning outcomes observable and assessable. When objectives are clearly stated, teachers can better align instructional methods and assessment tasks to ensure that learners achieve the intended outcomes. The strong confidence demonstrated by the students in the present study indicates their readiness to apply this principle in their lesson planning, suggesting a sound foundation in designing lessons that are goal oriented and assessable.

Most students 78 (81.3%) reported that they were very confident in selecting suitable teaching methods for science lessons, while the remaining 18(18.7%) perceived themselves as confident. This pattern suggests that the majority of the participants do not experience significant difficulty in choosing appropriate instructional strategies that match the content and learning needs in science education. A longitudinal analysis of instructional practices reported that teaching methods are pivotal to the success of educational systems because they ensure that students acquire the competencies embedded in the curriculum and remain actively engaged in the learning process (A. R. Aguilar-Moya et al., 2025).

On integrating learner-centered approaches, the results of this study revealed that 87(90.6%) of the students reported being very confident and the remaining 9(9.4%) felt confident, indicating that nearly all participants perceive themselves as able to implement learner-centered instructional strategies effectively. This high level of confidence suggests that students recognize the value of learner-centered practices and feel prepared to apply them in science teaching contexts. Research on learner-centered pedagogies highlights that shifting the classroom focus from teacher-directed instruction to student-focused learning fosters active participation,

collaboration, and critical thinking, which are foundational for deeper conceptual understanding and lifelong learning skills (Mir, 2024).

On planning lessons that consider learners’ prior knowledge, the findings from this study indicate an overwhelmingly high level of confidence among students, with 93(96.9%) reporting that they were very confident and only 3(3.1%) feeling confident. This suggests that nearly all participants perceive themselves as capable of incorporating learners’ existing knowledge into their instructional planning, an essential skill for effective teaching. Prior knowledge refers to what learners already know before engaging with new material, and it serves as a foundational scaffold upon which new learning is constructed. Recent integrative research on the role of prior knowledge in learning highlights that it influences a wide range of cognitive processes such as encoding, comprehension, and transfer of new concepts and significantly shapes learning outcomes when effectively activated and connected to instruction (Schneider & Simonsmeier, 2025).

Overall, the findings indicate that the majority of students perceive themselves as highly competent in key aspects of lesson planning and curriculum interpretation, with most respondents reporting being very confident across all four components. Specifically, students demonstrated strong confidence in writing clear and measurable lesson objectives, selecting appropriate teaching methods, integrating learner-centered approaches, and planning lessons that consider learners’ prior knowledge. This overall pattern suggests that the participants feel well-prepared to design and implement science lessons that are goal-oriented, learner-centered, and aligned with curriculum expectations. The high levels of confidence across these areas may reflect effective training and understanding of essential instructional planning skills, which are critical for promoting meaningful learning experiences and improving teaching effectiveness in science education.

### **Inquiry-based Learner-centered teaching**

Inquiry-based, learner-centered teaching is an instructional approach that positions students as active participants in the learning process by engaging them in questioning, investigation, and knowledge construction rather than passive reception of information. Grounded in constructivist learning theory, this approach emphasizes learners’ prior knowledge, curiosity, and autonomy, enabling them to develop critical thinking, problem-solving, and lifelong learning skills through meaningful exploration of real-world problems. By shifting the teacher’s role from knowledge transmitter to facilitator, inquiry-based learner-centered teaching fosters deeper understanding, higher motivation, and greater ownership of learning outcomes, making it particularly valuable in preparing learners for complex and dynamic academic and professional contexts (Prince & Felder, 2006). Students’ confidence levels Inquiry-based Learner-centered teaching are summarized in the table below.

<b>Inquiry-based Learner-centered teaching</b>	Very Confident		Confident		Moderately confident		Total	
	F	%	F	%	F	%	F	%
Incorporate inclusive education strategies in a science lesson	72	75,0	20	20,8	4	4,2	96	100
Use learner-centered teaching methods in science lessons.	83	86,5	12	12,5	1	1,0	96	100
Apply inquiry-based learning strategies	86	89,6	10	10,4	0	0,0	96	100
Use demonstrations to explain abstract science concepts.	83	86,5	11	11,5	2	2	96	100
Engage students actively during science lessons.	90	93,8	6	6,2	0	0,0	96	100

Ask effective questions to promote critical thinking.	86	89,6	10	10,4	0	0,0	96	100
Adjust teaching strategies based on learners' responses	85	88,5	11	11,5	0	0,0	96	100

Source: Primary data (2026)

On incorporating Inclusive Education Strategies in a Science Lesson, Out of 96 respondents, 72 students (75.0%) reported being very confident, 20 (20.8%) were confident, and 4 (4.2%) were moderately confident in incorporating inclusive education strategies in science lessons. This distribution indicates that the majority of TTC Nyamata final-year students feel capable of addressing diverse learners' needs within inquiry-based, learner-centered classrooms.

According Florian and Spratt (2013), teacher confidence in inclusive strategies is strongly associated with exposure to inclusive pedagogy during pre-service training. The high level of confidence observed suggests that the teacher education program may have effectively integrated inclusive education principles, which are central to learner-centered teaching and equitable participation in inquiry-based learning.

The results show that 83 students (86.5%) felt very confident, 12 (12.5%) were confident, and only 1 student (1.0%) was moderately confident in using learner-centered teaching methods in science lessons. This demonstrates a very strong inclination toward learner-centered pedagogical practices among the respondents. This aligns with research by Weimer (2013) and Kember (2016), who emphasized that learner-centered teaching enhances students' autonomy, engagement, and conceptual understanding. Similarly, Schweisfurth (2015) noted that teacher confidence is a key determinant of successful learner-centered implementation, reinforcing the relevance of these results in suggesting readiness to apply such methods in real classroom contexts.

Regarding applying Inquiry-Based Learning Strategies, 86 students (89.6%) indicated being very confident, 10 (10.4%) were confident, and none reported being moderately confident in applying inquiry-based learning strategies. This suggests a uniformly high level of confidence in facilitating inquiry processes. These findings are in line with studies by Lazonder and Harmsen (2016), which reported that inquiry-based learning is most effective when teachers are confident in guiding students through questioning, investigation, and reasoning. The high confidence reported by TTC Nyamata final year students highlights the relevance of inquiry-based approaches in modern science education and suggests that pre-service training has equipped them with essential inquiry facilitation skills.

**On the Use of Demonstrations to Explain Abstract Science Concepts**, data indicate that 83 students (86.5%) were very confident, 11 (11.5%) were confident, and 2 (2.0%) were moderately confident in using demonstrations to explain abstract science concepts. While the large majority expressed high confidence, the presence of a small proportion of students who are only moderately confident suggests that some final-year trainees may still experience challenges in effectively designing or implementing demonstrations, particularly when dealing with highly abstract scientific concepts. These challenges may be linked to limited hands-on practice, inadequate laboratory resources, or uncertainty in linking demonstrations to learners' prior knowledge and inquiry questions. Research by Abrahams and Millar (2017) supports the effectiveness of demonstrations in enhancing conceptual understanding when they are thoughtfully planned and integrated with inquiry, questioning, and learner discussion. However, Abrahams and Reiss (2017) further note that teachers with limited pedagogical content knowledge may struggle to move beyond showing phenomena to helping learners interpret and explain them scientifically. The moderate confidence reported by a few students in this study is therefore relevant, as it highlights the need for continued support in helping pre-service teachers design interactive demonstrations that actively involve learners in prediction, observation, and explanation. Strengthening practical training and reflective teaching experiences can help these students transition from basic demonstration use to more inquiry-driven and learner-centered applications.

The majority of respondents, 90 students (93.8%), reported being very confident, while 6 (6.2%) were confident, and none were moderately confident in actively engaging students during science lessons. This represents the highest confidence level among all elements. This result strongly corresponds with findings by Prince and Felder (2014), who demonstrated that active engagement significantly improves student learning outcomes in science education. The high confidence levels underscore the relevance of active learning as a core component of inquiry-based learner-centered teaching and indicate strong preparedness to foster interactive learning environments.

On asking effective questions to Promote Critical Thinking, the results reveal that 86 students (89.6%) felt very confident, 10 (10.4%) were confident, and none were moderately confident in asking effective questions to promote critical thinking. This suggests strong perceived competence in questioning techniques. Walsh and Sattes (2017), emphasized that effective questioning is fundamental to inquiry-based teaching and the development of higher-order thinking skills. The relevance of this result lies in the recognition that questioning drives inquiry, reflection, and conceptual change, making it a critical skill for learner-centered science teaching.

Finally, 85 students (88.5%) reported being very confident, 11 (11.5%) were confident, and none were moderately confident in adjusting teaching strategies based on learners' responses. This indicates strong confidence in adaptive and responsive teaching practices, which is consistent with findings by Black and Wiliam (2018) and Tomlinson (2017) who stated that adaptive teaching and responsiveness to learners' feedback are essential for effective learner-centered and inquiry-based instruction. The high confidence reported in this study is relevant, as it suggests readiness to use formative assessment and learner feedback to guide instructional decisions and support meaningful learning.

### Practical and Laboratory skills

Practical and laboratory skills are essential components of teacher preparation, particularly for pre-service science teachers, as they enable future educators to translate theoretical knowledge into meaningful hands-on learning experiences for students. These skills support effective demonstration, experimentation, safety management, and the facilitation of inquiry-based and learner-centered learning, which are central to contemporary science education. According to Hofstein & Lunetta (2014), developing strong practical and laboratory competencies during pre-service training enhances teachers' confidence, instructional effectiveness, and ability to foster learners' scientific reasoning and problem-solving skills.

Practical and Laboratory skills	Very Confident		Confident		Moderately confident		Total	
	F	%	F	%	F	%	F	%
Use laboratory equipment safely and effectively	76	79,2	15	15,6	5	5,2	96	100
Select appropriate instructional materials for science teaching	78	81,3	17	17,7	1	1,0	96	100
Improvise teaching aids using locally available materials	74	77,1	14	14,6	8	8,3	96	100
Integrate ICT tools in teaching science	70	72,9	19	19,8	7	7,3	96	100
Prepare low-cost teaching aids for science lessons	72	75,0	20	20,8	4	4,2	96	100

Source: Primary data (2026)

Out of 96 respondents, 76 students (79.2%) reported being very confident, 15 (15.6%) were confident, and 5 (5.2%) were moderately confident in using laboratory equipment safely and effectively. This indicates that most TTC Nyamata final-year students feel well prepared to handle laboratory apparatus, though a small proportion

still lacks full confidence. Research by Hofstein and Kind (2015) emphasizes that practical competence and safety awareness are foundational for effective science teaching. The presence of moderately confident students suggests the need for more structured laboratory practice and explicit safety training within teacher education programs. Strengthening repeated hands-on experiences and supervised laboratory sessions can further enhance confidence and preparedness for real classroom laboratory settings.

On selecting Appropriate Instructional Materials for Science Teaching, the results show that 78 students (81.3%) were very confident, 17 (17.7%) were confident, and only 1 student (1.0%) was moderately confident in selecting appropriate instructional materials for science teaching. This reflects a strong ability to align teaching materials with lesson objectives and learners' needs. According to Davis and Krajcik (2015), the ability to select suitable instructional materials is a key aspect of pedagogical content knowledge for science teachers. The high confidence levels observed suggest that the teacher training program has effectively supported students in evaluating and choosing relevant resources. This competence is particularly relevant in teacher education, as it directly influences lesson quality and learner engagement.

Regarding Improvising Teaching Aids Using Locally Available Materials, among the respondents, 74 students (77.1%) indicated being very confident, 14 (14.6%) were confident, and 8 (8.3%) were moderately confident in improvising teaching aids from locally available materials. Although the majority reported high confidence, this element recorded one of the highest proportions of moderate confidence, suggesting that a noticeable group of pre-service teachers may still face challenges in creatively transforming local materials into effective instructional resources. Studies by Mupa and Chinooneka (2015) emphasized that improvisation skills are particularly critical in resource-constrained educational contexts where standard laboratory equipment is scarce or unavailable. In many schools, especially in rural and under-resourced settings, shortages of laboratory materials limit opportunities for practical science learning. The presence of moderately confident students in this study is therefore significant, as it may reflect limited exposure to hands-on improvisation tasks during training or uncertainty about aligning improvised materials with scientific accuracy and lesson objectives. Kind and Osborne (2017) further note that well-designed improvised teaching aids can enhance learners' conceptual understanding and engagement when teachers are adequately trained to use them effectively. For teacher training programs, strengthening practical coursework that focuses on designing, testing, and reflecting on improvised teaching aids is highly relevant. Such preparation equips future teachers to overcome material shortages, sustain inquiry-based learning, and ensure that practical science teaching remains effective even in schools with limited laboratory resources.

Integrating ICT Tools in Teaching Science, data indicates that 70 students (72.9%) were very confident, 19 (19.8%) were confident, and 7 (7.3%) were moderately confident in integrating ICT tools in science teaching. Compared to other elements, this area shows relatively lower levels of very high confidence. Tondeur et al. (2017) and Scherer et al. (2019) suggests that effective ICT integration depends on both technical skills and pedagogical understanding. The moderate confidence reported by some students highlights the need for teacher training programs to provide more structured and hands-on ICT integration experiences. Strengthening digital pedagogy within pre-service education is particularly relevant as technology-enhanced learning becomes increasingly central to modern science education.

On Preparing Low-Cost Teaching Aids for Science Lessons, 72 students (75.0%) reported being very confident, 20 (20.8%) were confident, and 4 (4.2%) were moderately confident in preparing low-cost teaching aids for science lessons. This indicates a generally strong ability to design affordable instructional resources. According to UNESCO (2016) the ability to design low-cost teaching aids is crucial for ensuring equitable access to quality science education, especially in under-resourced schools. The high confidence levels observed are therefore highly relevant for teacher training programs, as they suggest that pre-service teachers are being adequately prepared to adapt instruction to diverse school contexts while maintaining effective practical learning experiences.

## Assessment and Evaluation

Assessment and evaluation are vital components of teacher preparation, as they enable pre-service teachers to monitor learners' progress, inform instructional decisions, and improve learning outcomes. Effective assessment

practices support learner-centered and inquiry-based teaching by providing timely feedback, identifying learning gaps, and guiding the adaptation of teaching strategies to learners’ needs. Developing strong assessment and evaluation competencies during pre-service training enhances teachers’ ability to use formative and summative assessment tools to promote meaningful learning and accountability (Black & Wiliam, 2018). Students confidence levels in Assessment and Evaluation competencies are summarized in the table below.

Assessment and Evaluation	Very Confident		Confident		Moderately confident		Total	
	F	%	F	%	F	%	F	%
Design assessment tools that measure learners’ competencies.	85	88,5	5	5,2	6	6,3	96	100
Prepare tests and quizzes aligned with lesson objectives.	90	93,8	6	6,3	0	0,0	96	100
Use formative assessment during science lessons.	93	96,9	3	3,1	0	0,0	96	100
Provide constructive feedback to learners.	95	99,0	1	1,0	0	0,0	96	100
Use assessment results to improve teaching.	91	94,8	4	4,2	1	1,0	96	100

Source: Primary data (2026)

Out of 96 respondents, 85 students (88.5%) reported being very confident, 5 (5.2%) were confident, and 6 (6.3%) were moderately confident in designing assessment tools that measure learners’ competencies. This indicates that most students believe they can develop assessments aligned with competency-based learning, although a small proportion still feels less confident. This finding aligns with Gulikers, Biemans, and Mulder (2017), who argue that competency-based assessment is essential for evaluating learners’ application of knowledge and skills. The presence of moderately confident students suggests that teacher training programs should further emphasize authentic and performance-based assessment design to ensure all pre-service teachers can confidently assess competencies rather than rote knowledge.

On Preparing Tests and Quizzes Aligned with Lesson Objectives, the results show that 90 students (93.8%) were very confident and 6 (6.3%) were confident, with none reporting moderate confidence, in preparing tests and quizzes aligned with lesson objectives. This reflects a very strong understanding of alignment between instruction and assessment. According to Biggs and Tang (2015), constructive alignment between learning objectives, teaching activities, and assessment is a cornerstone of effective teaching. The high confidence reported here is highly relevant for teacher training programs, as it suggests that pre-service teachers are well prepared to design coherent assessments that accurately reflect intended learning outcomes.

Among the respondents, 93 students (96.9%) indicated being very confident and 3 (3.1%) were confident in using formative assessment during science lessons, with no students reporting moderate confidence. This shows near-universal confidence in formative assessment practices which strongly supports the work of Black and Wiliam (2018), who demonstrated that formative assessment significantly improves learning by informing both teaching and learner understanding. For teacher training programs, this finding is particularly relevant, as it indicates successful preparation of pre-service teachers to integrate assessment into daily instruction rather than treating it as a separate activity.

On Providing Constructive Feedback to Learners, data indicates that 95 students (99.0%) were very confident, 1 (1.0%) was confident, and none were moderately confident in providing constructive feedback to learners. This represents the highest confidence level across all assessment elements. Research by Hattie and Timperley (2017) highlights feedback as one of the most powerful influences on student learning when it is timely, specific, and focused on improvement. The extremely high confidence reported suggests that teacher training programs

have effectively emphasized feedback as a key pedagogical skill, which is crucial for learner-centered and competency-based education.

Concerning Using Assessment Results to Improve Teaching, 91 students (94.8%) reported being very confident, 4 (4.2%) were confident, and 1 (1.0%) was moderately confident in using assessment results to improve teaching. This indicates strong confidence in reflective and data-informed teaching practices. This is consistent with research by Datnow and Hubbard (2016), which emphasizes the importance of using assessment data to guide instructional improvement. Its relevance for teacher training programs lies in preparing future teachers to be reflective practitioners who continuously adapt their teaching based on evidence of learners' progress.

### Classroom Management and Communication

Classroom management and communication are foundational skills for pre-service teachers, as they directly influence the learning environment, student behavior, and the effectiveness of instruction. Strong classroom management helps maintain order, create a safe and respectful atmosphere, and maximize instructional time, while effective communication supports clear lesson delivery, positive teacher–student relationships, and meaningful feedback. Developing these competencies during teacher training is essential for preparing teachers to handle diverse classroom dynamics and promote student engagement and achievement (Emmer & Stough, 2014).

Classroom Management and Communication	Very Confident		Confident		Moderately confident		Total	
	F	%	F	%	F	%	F	%
Maintain discipline during science lessons.	94	97,9	2	2,1	0	0,0	96	100
Manage time effectively in a science lesson	93	96,9	3	3,1	0	0,0	96	100
Communicate science concepts clearly to learners	85	88,5	11	11,5	0	0,0	96	100
Create a supportive learning environment	92	95,8	3	3,1	1	1,0	96	100
Handle learners' questions confidently.	86	89,6	10	10,4	0	0,0	96	100
Manage large classes during science teaching	88	91,7	4	4,2	4	4,2	96	100

Source: Primary data (2026)

As shown in the above table, Out of 96 respondents, 94 students (97.9%) reported being very confident, 2 (2.1%) were confident, and none (0.0%) were moderately confident in maintaining discipline during science lessons. This indicates near-universal confidence in classroom discipline management. Strong classroom management is crucial for minimizing disruptions and creating a conducive learning environment (Oliver and Reschly, 2017). For teacher training programs, the high confidence is encouraging, as it suggests that students are well-prepared to establish clear rules, routines, and expectations. However, real classroom contexts can present unpredictable behaviors, so continuous practical exposure and mentorship are necessary to ensure sustained effectiveness.

The results show that 93 students (96.9%) were very confident, 3 (3.1%) were confident, and none were moderately confident in managing time effectively during science lessons. This indicates that students perceive themselves as capable of pacing lessons and allocating time for instruction and activities. Stronge and Hindman (2017) emphasizes that effective time management enhances lesson flow and student engagement. It also reduces idle time, which can lead to disciplinary issues. Teacher training programs should reinforce this skill through micro-teaching, lesson planning, and classroom simulations, as strong time management is essential for implementing inquiry-based and practical science activities within limited lesson periods.

Among the respondents, 85 students (88.5%) indicated being very confident and 11 (11.5%) were confident in communicating science concepts clearly, with none reporting moderate confidence. This suggests strong perceived ability to explain scientific ideas in understandable terms. Kuo, Hsiao, and Tsai (2019), shows that clear communication and language clarity are essential for learners to grasp complex scientific concepts. Teacher training programs should continue emphasizing pedagogical content knowledge and communication strategies, including the use of analogies, examples, and simple language, as clear communication directly affects students' conceptual understanding and engagement.

On Creating a Supportive Learning Environment, 92 students (95.8%) were very confident, 3 (3.1%) were confident, and 1 (1.0%) was moderately confident in creating a supportive learning environment. This indicates a strong perception of their ability to establish positive classroom relationships and emotional safety. Supportive learning environments improve students' emotional well-being and academic outcomes (Jennings and Greenberg, 2014). For teacher training programs, this result is highly relevant because creating a supportive classroom culture is foundational for learner-centered teaching and effective classroom management. Continued focus on socio-emotional skills and inclusive practices will further strengthen this competence.

Regarding Handle Learners' Questions Confidently, results reveal that 86 students (89.6%) were very confident and 10 (10.4%) were confident in handling learners' questions confidently, with no students reporting moderate confidence. This suggests strong perceived ability to respond to learners' inquiries and stimulate curiosity. Mercer and Littleton (2017), indicates that effective teacher-student dialogue enhances critical thinking and deeper learning. Teacher training programs should thus continue to train pre-service teachers in dialogic teaching strategies, including how to respond to divergent answers and how to use questions to promote reasoning.

Finally, 88 students (91.7%) reported being very confident, 4 (4.2%) were confident, and 4 (4.2%) were moderately confident in managing large classes during science teaching. Although most students are confident, this element shows the highest proportion of moderate confidence, indicating potential concern about handling overcrowded classrooms. Blatchford, Bassett, and Brown (2016) highlights that large class sizes can negatively affect teacher-student interaction, classroom management, and student achievement. For teacher training programs, this finding is highly relevant as it points to the need for specific strategies for large-class management, such as group work organization, peer teaching, and classroom zoning. Strengthening pre-service training in these techniques can help future teachers maintain effective learning environments even in overcrowded classrooms.

## CONCLUSION AND RECOMMENDATIONS

The findings revealed that final-year students at TTC Nyamata generally perceive the development of science didactic competencies as highly effective. Across key domains such as Lesson Planning and Curriculum Interpretation, Pedagogical Content Knowledge, inquiry-based learner-centered teaching, practical and laboratory skills, assessment and evaluation, and classroom management and communication. Most students reported being very confident in applying these competencies. This suggests that the teacher training program at TTC Nyamata successfully equips pre-service science teachers with the pedagogical knowledge, practical skills, and classroom management abilities needed to deliver effective science instruction. The consistently high confidence levels indicate that students feel prepared to implement learner-centered approaches, design and use appropriate assessment tools, and manage science lessons efficiently. These results are consistent with research emphasizing that robust teacher education programs improve teaching self-efficacy and instructional quality, particularly when they integrate practical training and reflective pedagogy (Bong & Skaalvik, 2020). Despite the overall positive perception, the data also revealed specific areas where confidence is slightly lower, particularly in improvising teaching aids with locally available materials, integrating ICT tools, and managing large classes. These results imply that while TTC Nyamata's training program is strong in core didactic competencies, there are contextual challenges such as resource constraints, limited access to technology that may affect pre-service teachers' readiness for real classroom environments. Research indicates that teacher confidence in applying instructional innovations is strongly influenced by access to resources and sustained practical experience, meaning that gaps in these areas can hinder the transfer of training to actual classroom practice (Tondeur et al., 2019). Therefore, the program may benefit from further strengthening practical exposure and support in these

areas to ensure that all graduates can adapt effectively to the realities of Rwandan schools. To enhance the effectiveness of science didactic competence development, TTC Nyamata should reinforce practical training opportunities focused on resourcefulness and context-based teaching, including workshops on improvising teaching aids, ICT integration, and strategies for managing large classes. Additionally, the college should strengthen partnerships with schools and educational stakeholders to provide more field-based practice and access to laboratory resources, ensuring that all pre-service teachers gain hands-on experience and confidence in handling real classroom challenges. Emphasis should also be placed on continuous professional development and mentorship during teaching practice to support the transition from training to real-world teaching contexts.

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